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THE CEAL PROPANE GALLERY TEST

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THE CEAL PROPANE GALLERY TEST

by

K.J. Mintz*

ABSTRACT

The propane gallery test, also known as the flame propagation test, is used for determining the flammability of conveyor belting. It is of sufficiently large scale that the results are considered to be directly applicable to the situation in underground mines and has been incorporated into the Canadian National Standard M422-M87, to which CEAL tests fire-resistant conveyor belting for certification purposes. This report describes this test and gives the operating and maintenance procedures now in effect at CEAL.

KEYWORDS: conveyor belting, flammability tests, propane gallery

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L'ESSAI AU PROPANE EN GALERIE EFFECTUÉ PAR LE LCRAE

par

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RÉSUMÉ

L'essai au propane en galerie, également appelé l'essai de propagation de la flamme, est utilisé pour déterminer l'inflammabilité des courroies de convoyeur. Il est effectué à une échelle suffisamment grande pour nous permettre de croire que les résultats sont directement applicables à la situation qui existe dans les mines souterraines et il a été incorporé à la norme canadienne nationale M422-M87, à partir de laquelle le LCRAE effectue des essais sur les courroies de convoyeur inflammables à des fins d'homologation. Le présent rapport décrit l'essai et explique les procédés de fonctionnement et d'entretien en vigueur au LCRAE.

MOTS-CLÉS: courroies de convoyeur, essais d'inflammabilité, galerie d'essai au propane.

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INTRODUCTION

The propane gallery is a medium-scale test used for the evaluation of the flammability of conveyor belting. It is used in several countries as part of their certification procedures of conveyor belting for underground mines (1,2,3).

The CEAL version was built in 1982 in anticipation of the Canadian Standard on conveyor belting. Many tests were carried out using the procedures given in other standards as well as various modifications in order to decide on the appropriate tests for Canada (4,5). The Standard was eventually completed and published in May this year (6), incorporating the propane gallery test as part of the certification procedure for Types A1, A2, B1-A, B1-B and B2. (Type C, which corresponds approximately to the previous EMR specifications, does not require this test). The Certification Officer has formally implemented testing to M422 as of August 1987 and therefore the propane gallery has now become a routine certification test.

The purpose of this report is to describe the propane gallery and to provide the operating and maintenance instructions for it.

DESCRIPTION

A propane gallery consists of a 2 meter square chamber with air travelling through it at a mean velocity of 1.5 m/s. A piece of conveyor belting is placed on a trestle (Fig. 1) and ignited by a propane burner (Fig. 2). The material of the chamber, the size of conveyor belting, the flow rate of propane to the burner, the time that the burner is left in place and the pass/fail criteria vary for different certification agencies.

CEAL has, at present, the only propane gallery in North America. (The U.S.A (USBM/MSHA) is considering having this test). Other propane galleries exist in the U.K. (National Coal Board (7) and Scandura, Inc.), Belgium, France, West Germany and Australia (Australia uses a 2.7 m diameter tube).

The CEAL version of the propane gallery differs from other countries' versions in that it was built inside an existing building.

Several problems arise as a result:

1. The air flow must make a 90° turn only about .6 m before the front of the belt, which makes it very difficult to produce a homogeneous stream of air. (By contrast, in the NCB facility (7), the belt is placed 8 m away from the front of the gallery). Louvers and a screen have been installed to straighten out the air flow. The system is not perfect: the flow rate is slightly higher on the side away from the observer. The effect is to slightly increase the extent of burning on that side. For a test of this magnitude, however, this problem will not substantially affect the results. It should be noted in this context that, in large-scale tests carried out at the U.S. Bureau of Mines, the 1.5 m/s is optimal with respect to maximizing flame spread and that a small change in velocity does not affect the propagation significantly (8).
2. The chamber is made of steel with no insulation. Other galleries use insulation. The CEAL version, therefore, is somewhat less severe because of heat loss. At the present time, the effect of this parameter on the results has not been quantified. Because of severe space restrictions around the gallery, installation of insulation would be a problem.
3. With a standard 4 m length, the end of the sample is only about 1 m from the exit. This, again, may have an effect on the air flow in that area. This is, however, not considered to be a serious problem, because samples that burn to that area fail the test.
4. The space available for bringing in and removing the beltings is severely limited. An opening has been cut in the concrete wall and a back door made in the gallery to allow use of a hand lift. Although these changes have improved the materials handling, it remains somewhat awkward, particularly for steel-cord belting.

The propane flow in the CEAL gallery is controlled by a Brooks 5812B mass flow sensor connected to a 5871 secondary electronics and 5837 mass flow control valve. The 5871 contains a digital display in L/M of propane and a set-point potentiometer. The flowmeter was calibrated at the factory

to be accurate within 0.8% within the range of 0-100 L/M. A Brooks 450 integrator connected to the secondary electronics provides a check by giving the total amount of propane used.

At present, two K-type thermocouples, connected to digital displays which are connected to an Omega two-pen chart recorder, are used to monitor the temperature of the combustion gases. One is located near the roof about the end of the sample, the other is located in the exhaust duct between the chamber and the scrubber. The NCB facility (7) uses 25 thermocouples in a 5 x 5 array located 2 meters from the end of the belt (as well as measuring oxygen, CO, CO_2, and air velocity). Although, from the scientific viewpoint, these measurements are desirable, from the viewpoint of routine certification tests, the temperature measurements are only important so as to know when the fire has reached such an intensity as to be capable of causing damage to the facilities. The CSA Standard allows the operator to terminate the test if the temperature exceeds 200°C. However, if the temperature is not rising too quickly, then up to about 250°C can be tolerated for research tests. For routine certification tests, the temperature should be restricted to 200°C.

A hose connected to the water supply is used to put out fires inside the gallery as necessary. A small flap allows the operator to put the hose nozzle through the wall of the chamber. This flap was originally installed to allow the remote measurement of air velocity inside the chamber, because the air velocity measurement is significantly affected by the presence of obstacles.

Ambient temperature has been shown to have a significant effect on the performance of belting in the propane gallery (5). With the very large flow rate of air passing through the chamber, it is impractical to heat this air. Therefore, for practical purposes, the air temperature can be taken as that of the outside air. To prevent false passes, the minimum temperature allowed in the M422 Standard is 0°C. To prevent false failures, the maximum temperature allowed is 30°C. The justification for that range of temperature is that it corresponds to Canadian mines.

The test as specified is a combination of an ignition and a propagation test (even though it is referred to in the standard as a flame propagation test). If the entire belt immediately above the burner is consumed during the application of the burner as may happen with a very thin belt, then that test can be considered as a pure propagation test.

Although the propane gallery is set up for testing to the Canadian Standard M422, the so-called high-energy burn, used at the NCB for thick beltings, can also be carried out. The set-point on the mass controller is set to give 82.5 L/m and the burner applied for 50 minutes. The propane flow system is calibrated up to 100L/min. It would be difficult to use higher flow rates because the liquid propane cools during evaporation.

Propane gallery tests produce copious quantities of noxious smoke and fumes, which are unacceptable from the environmental view. Therefore, a flooded bed scrubber was purchased and installed at the time that the propane gallery was built. Although the operation of the scrubber has been optimized as much as possible and an improved smokestack built, some odour still occurs when PVC beltings are tested. Therefore, tests are now carried out only after normal working hours. When a rubber belting fails or nearly fails the test, the amount of combustion gases will for a short time exceed the capacity of the scrubber and black smoke will be emitted. Normally, the colour of the smoke will be white to light gray or light brown. At the time of writing, the formal tests for approval of the facility by the Ontario Ministry of the Environment are scheduled for October 1987.

The water used in the scrubber quickly becomes contaminated from the smoke from the burning conveyor belt. All fire-resistant belts, particularly those with PVC covers, produce large quantities of HCl. Most of the HCl is dissolved in the scrubber water which then becomes very acid. It is necessary to add sodium carbonate (soda ash) to neutralize the acid in order to maintain the efficiency of the scrubber and to prevent the acid from reacting with the steel walls of the sump. Defoamer is also required so that the particulates will be wetted out and captured by the scrubber. In order to maintain the scrubber at maximum efficiency, the packing materials must be cleaned by circulating clean water with detergent and antifoam added.

In large-scale tests by the U.S. Bureau of Mines, the measurement of HCl in the burning zone yielded small values (8). A recent study by Beitel et al (9) indicated that the HCl disappears quickly from the atmosphere surrounding a fire and they concluded that "the fire hazard of chlorine-containing materials is greatly exaggerated". The fact that so much HCl is captured in our scrubber can only be made compatible with the USBM work if it is assumed that the HCl is absorbed in the particles and is

leached out by the waste water. Some evidence for this hypothesis is that the pH of the sump water decreases slowly after completion of the test when the sump water is continuing to circulate. However, acid-containing smoke particles would still seem to present a possible health hazard.

The sump water has been analyzed (10) and has been shown, although not very hazardous, to be unsuitable for either the storm or sanitary drain. Therefore, on the advice of Environment Canada, a large evaporative pond was built behind the building. The idea is to evaporate the water and leave behind the particulates. If the system works as planned, it should not be necessary to clean out the pond more than once every 20 years or so.

OPERATING PROCEDURES

Two persons must be present when a fire test is being carried out or the propane burner is on. The directors of ERL and MRL must be notified of tests at least one day in advance.

IF, DURING A TEST, THE TEMPERATURE OF EITHER THERMOCOUPLE EXCEEDS 200°C, IMMEDIATELY TURN OFF THE PROPANE AND EXTINGUISH THE FIRE.

1. Check that the propane cylinder is at least 20% full. (Weigh it if in doubt).
2. Turn on the mass flowmeter and integrator. Allow at least 10 minutes to warm up.
3. Turn on the digital thermocouple readouts and the recorder.
4. Check that the two thermocouples are indicating the correct temperatures.
5. Check that the pens on the recorder are writing.
6. Fill sump with clean water to the level of the bar inside the sump.
7. Add about 15 L of soda ash and 4 L of EXFOAM 6002 to sump. Put the lid of the sump on and put the plastic funnel into one of the holes in the lid.
8. Pour about 15 ml of pH 10 buffer into a disposable plastic beaker.
9. Immerse the electrode of the Fisher portable pH meter into this beaker and adjust the calibration so that it reads 10.0. If the battery low indicator is lit, replace the 9V battery. Turn the switch off when not taking a measurement.

10. Put the bottom part of the electrode into the sump through the hole in the lid; the pH should be between 9 and 11.
11. Turn the breaker panel switch to "pump only", then turn the sump pump switch to "on". The motor should start; the pressure on the gauge should read about 30 psi, and the water level should drop about 25 mm. Check for unusual noises. Turn the sump pump switch to "off".
12. Turn the breaker panel switch to "fan and pump", then turn the toggle switch to "manual", and push the "start" button of the fan switch. Listen for unusual noises. The sump pump should start after about 10 seconds, and again should read about 30 psi. The pressure differential as read on the manometer should be about 3 inches water.

    Push the "stop" button of the fan switch.
13. Prepare the lighter by attaching two matches to a metal rod.
14. Light the matches.

    Operator #1: Make sure that the small outlet valve on the propane regulator is closed, open the valve of the cylinder, and adjust the regulator to read 20 psi; then open the outlet valve slightly.

    Operator #2: Place the end of the ignitor rod just above the burner, until it is lit.
15. Operator #2: Leave the chamber $d close the door.

    Operator #1: Turn the propane outlet valve completely open. The flowmeter should read 71.5 $\pm$ 0.5 L/M after a minute, and the integrator should be operating. Check that all 52 jets are working. If not, clean them and test again. Turn off the cylinder.
16. Set the sample in position on burner. The near end of the sample should be even with the first bar of the trestle; the sample should be equidistant from each side wall. Note that two tests are required on each product: one with the pulley side down, the other with the carrying side down.
17. Tie both ends of the sample to the trestle with wire. The sample should lie flat.
18. Check that the emergency hose is operational.
19. Turn on the recorder; set the speed at 1 cm/min. Zero the integrator. Turn the toggle switch to "timer".

20. Light the burner as in 13-14.
21. Operator #2: Exit the chamber, close the door, turn on the fan switch and start the timer.

    Operator #1: Open the propane outlet valve completely.
22. After about a minute, the flow indicator should read 71.5 $\pm$ 0.5 L/M. Make a small adjustment on the setting potentiometer, if necessary. Because of cooling due to evaporation, the flow rate may drop slightly, particularly for long burner times and when the propane tank is close to empty.
23. During the test, the pH must be checked several times; add additional soda ash if the pH drops below 9.
24. Check the smoke emitted from the smokestack; it should be white to grey, but not black. If the smoke is too dark, add another 2 L of defoamer. Note the direction of the smoke.
25. Make a note if there is any smell inside the building.
26. Turn burner off at the specified time (10 min. for Types B1-A, B1-2, B2 and A belts of less than 10 mm thickness; 0.1 min. for each 0.1 mm of thickness for belts greater than 10 mm thickness), by turning off the propane cylinder valve.
27. Note the reading on the integrator.
28. Allow the sample to extinguish by itself and note the time required after the burner has been turned off. Turn off all the lights to allow clearer observation of the fire.
29. After the fire has completely gone out, turn the recorder and propane flow system equipment off. The fan timer will keep the fan on for 4 hours so as to prevent any residual fumes from entering the rest of the building.
30. After 4 hours or more have elapsed, remove the remains of the sample from the chamber (wear hooded coveralls, gloves and a respirator) and measure the length of undamaged belt remaining on both sides.
31. Clean the floor of the gallery, windows and lights. Wear hooded coveralls, gloves, and a respirator.
32. Place the portable sump pump in the sump, check to ensure that the end of the hose is near the water in the pond and pump out the entire contents of the sump. (Wear gloves and a lab coat or coveralls).

33. Fill the sump about half full with clean water, add about 2 L of defoamer and 1/4 of a package of Fisher Sparkleen detergent or equivalent.
34. Turn the breaker switch to "pump only", switch the pump switch to "on" and allow the water to circulate for at least 3 hours.
35. Pump out the sump as before.
36. Check the level of the pond and note it in the log book.

MATERIALS

1. pH 10 buffer solution - Fisher or Canlab
2. Defoamer - Exfoam 6002, 5 gal containers - Dearborn Chemicals
3. Soda Ash - 58% light, 40 kg bags - Lawrasons Chemicals
4. Detergent - Sparkleen - Fisher
5. Propane - Natural grade, 96% minimum, size 1F cylinders - Matheson or Linde. **NOTE:** Do not use commercial grade.

SAFETY EQUIPMENT

1. Safety glasses with sideshields are required at all times when carrying out a test or handling materials or waste.
2. Scott full facepiece respirator model 65 with organic vapors/acid gases cartridges and dust/mist filters, or equivalent.
3. Disposable hooded coveralls, "Kleengard" or equivalent.

MAINTENANCE AFTER EVERY TEN TESTS

BECAUSE OF THE WEIGHT OF THE COMPONENTS, TWO PEOPLE ARE REQUIRED

1. Remove the sump pump at the coupler.
2. Remove the lower plate of the scrubber.
3. With the fork-lift truck, remove the basket containing the packed bed.
4. Inspect the inside of the scrubber for corrosion damage.
5. Check that none of the pieces in the bed have melted or have been damaged. Replace pieces damaged or melted.

6. Re-install the sump pump.
7. Close the valve located just below the pressure gauge of the sump pump system.
8. Turn the breaker switch to "pump only" and turn the pump switch to "on".
9. Slowly turn the valve on and observe the flow of water from the four nozzles inside the scrubber. Turn pump switch to "off". Remove and clean any nozzle through which water is not spraying properly.
10. Remove the sump pump. Replace the scrubber bed and the lower scrubber plate. Replace the sump pump.

ANNUAL MAINTENANCE

1. Check the fan and its motor. (To be done by Technical Services Division (TSD), CANMET).
2. Check and grease bearings in the sump pump. (TSD)
3. By visual inspection at roof level, check that the smokestack is undamaged and that the green caulking is intact. Check that the inspection port can be opened with a screwdriver.
4. Check that the walls and ceiling of the gallery are not excessively corroded.
5. Calibrate the two thermocouples.
6. Steam-clean the inside of the gallery (to be done through an external contract).
7. Check that the evaporative pond and fences are intact.

CONCLUSIONS

The propane gallery facility has been developed to the point where it can be considered to be a routine laboratory tool for the evaluation of the flammability of conveyor belting to CSA Standard M422-M87 and for contract testing for similar flammability testing (e.g. different burner times, different propane flow rates, different sample configurations). Because of the hazard of large-scale tests and potential pollution problems associated with them, an engineer or scientist should provide direct supervision of all tests as well as accepting responsibility for the maintenance of the facility.

FURTHER WORK

At the time of preparation of this report, the evaluation of possible methods to optimize the operation of the existing scrubber is not complete. Specifically, the evaluation of replacing the original packing elements by saddle-shaped polypropylene pieces and the addition of sodium bisulphite to the pump water will be carried out in the near future.

The propane gallery facility has not yet been approved by the Ontario Ministry of the Environment. It is possible that further additions or modifications to the scrubber system will be required to obtain final approval. To eliminate the nuisance odours (particularly from PVC belting) so as to allow operation during working hours would probably require considerable additions to the system. The expense of this may not be justifiable on the basis of the current projected workload.

It is possible that, to conform with other countries' facilities, insulation in the form of a mineral fibre board may be added to the walls and ceiling of the gallery.

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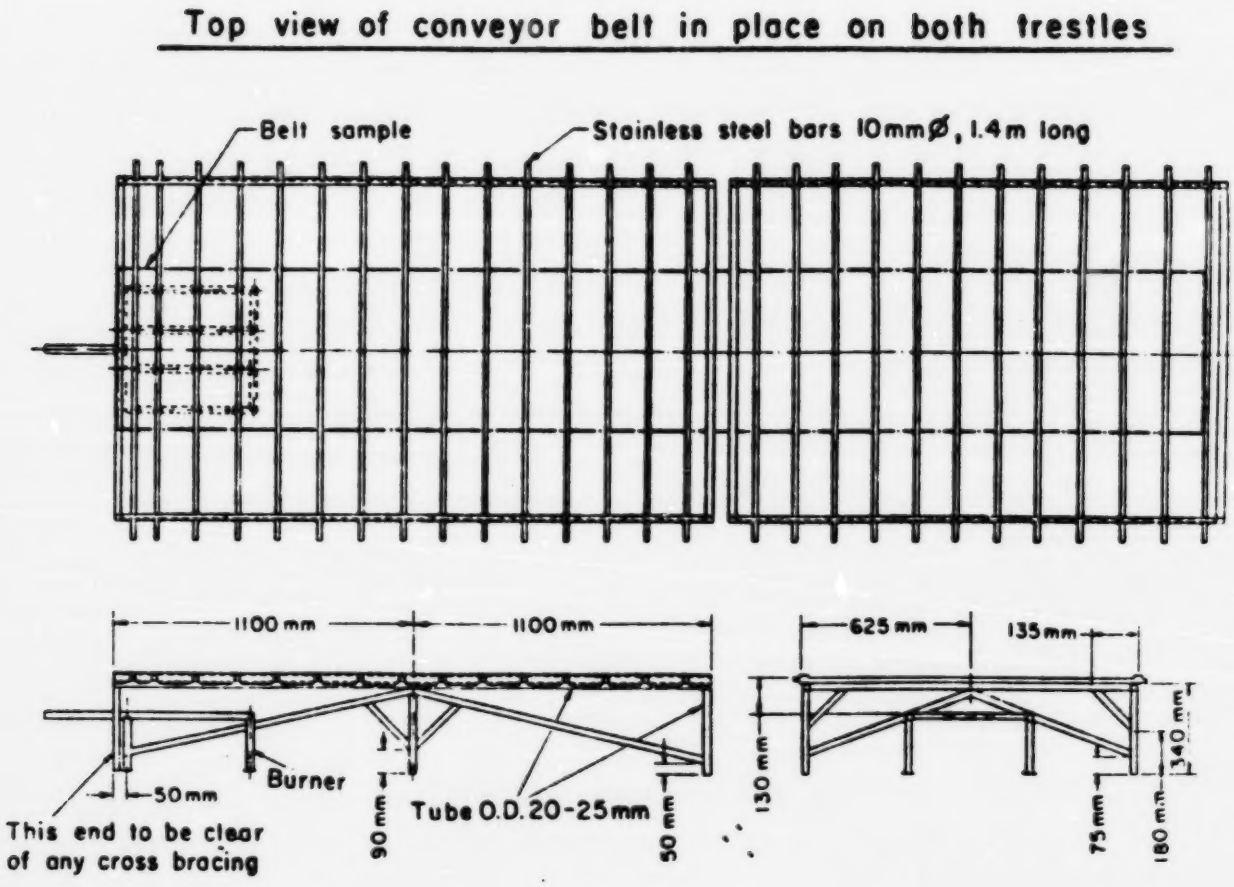

Fig. 1. Trestle for Propane Burner Test

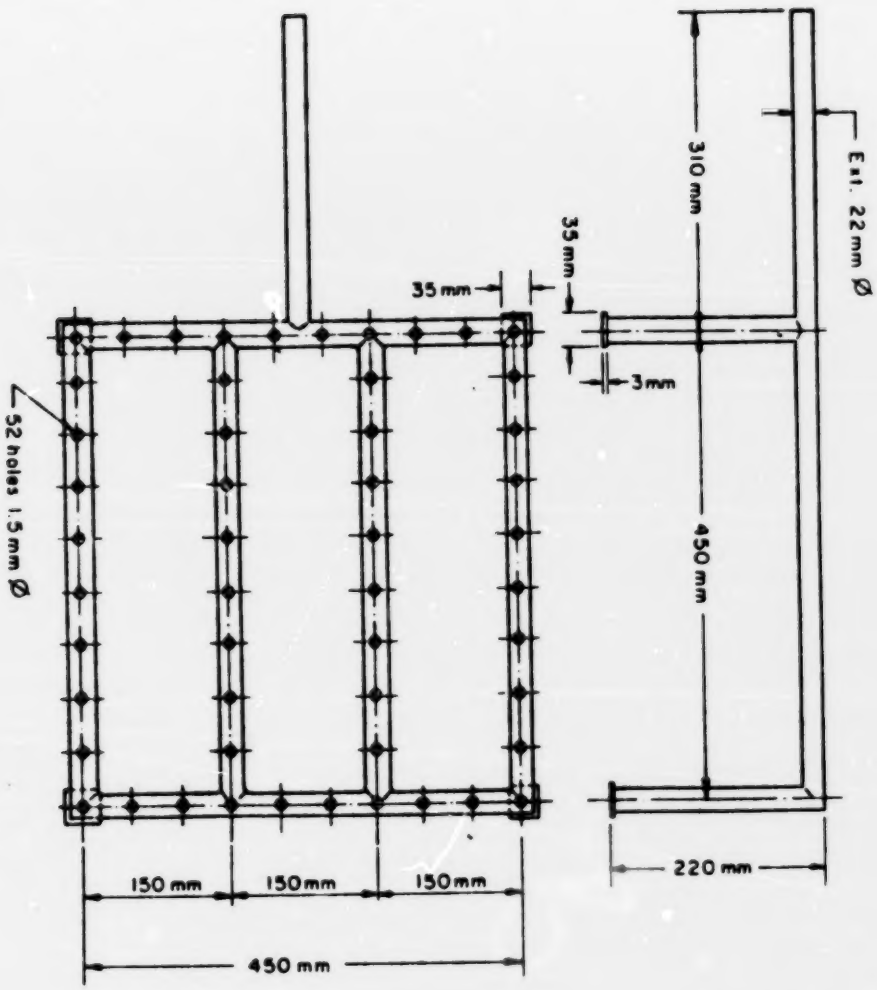

Fig. 2 - Propane Burner

FLAME PROPAGATION (PROPANE GALLERY) TEST TO CSA STANDARD M422-M87

File No. _____

Manufacturer _____ Operators _____

Sample _____ Witnesses _____

Cover Thicknesses _____ ☐ Certification Requested:

Total Thickness _____ ☐ A1 ☐ B1-A ☐ B1-B

☐ A2 ☐ B2

☐ Non-Certification _____

	TEST #1 PULLEY SIDE	TEST #2 CARRYING SIDE
Date/Time of Test		
Wind: direction velocity (km/h)		
Smoke: direction colour		
Any odour inside?		
Burner Time** (min.)		
Afterburn Time (min.)		
Propane: Rate of flow (LPM)*		
Total Consumed (L)		
Ambient Temp. (°C)		
Temp. at Shut-off (°C) T/C #1		
T/C #2		
Max. Temp. reached (°C) T/C #1		
T/C #2		
Length unburnt (cm) top		
Bottom		

* Should be 71.5 LPM (which is equivalent to 130 g/min).

**Should be 10 min. for Types B1 and B2, or 0.1 min. for each 0.1 mm of thickness (min. 10 min.) for Types A1 and A2.
Phone weather office (998-3440)

Comments: 1.

2.